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ABSTRACT

This paper examines the rapidly changing state of museum handhelds from both a technology and content perspective. The paper also discusses the component parts for a successful museum installation: content, user interface, applications, form factor, positioning and the challenges to integrating these components. Specific examples are demonstrated from the 2002 Tate Modern installation and the authors' own research. Tate Modern's Multimedia Tour Pilot, open to the public from July through September 2002, was a 45-minute tour of the Still Life/Object/ Real Life galleries, in which visitors could experience audio, video, still images and a variety of interactive applications on handheld iPAQ computers loaned by HP; the content of the multimedia tour was delivered to the visitor through the museum's wireless network, using location-based technologies. The paper concludes that wireless interactive systems offer important tools and unique opportunities for the development of in-gallery interpretation and education programs, and the extension of these to a cultural experience of the wider city that links many museums and visitor attractions. The visitor response to the Tate Modern Multimedia Tour Pilot has given an unequivocal green light to future development of these handheld solutions within the museum. (Contains 14 references.) (Author/AEF)

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The State Of The Art In Museum Handhelds In 2003

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Abstract

This paper examines the rapidly changing state of museum handhelds from both a technology and content perspective. The paper will also discuss the component parts for a successful museum installation: content, user interface, applications, form factor, positioning and the challenges to integrating these components. Specific examples will be demonstrated from the 2002 Tate Modern installation and the authors' own research.

Keywords: handhelds, tours, Tate Modern

Introduction: The Evolution of the Museum Handheld

In museum technology we are now at a major crossroads with the advent of next generation handhelds (PDAs). As described in previous papers (Tellis and Proctor, 2002; Tellis 2001), the 37 year history of audio guides in museums has seen a slow evolution from reel to reel tape to cassette to digital RAM, MP2 and now MP3 systems. In the first 35 years there were only two major technology shifts, the first being compact cassette in 1980 which greatly reduced the size of the players and the second being the transition from analog to digital systems in 1994.

The transition to digital was by far the most revolutionary as it freed the portable audio experience from the 45-minute time limit and single, forced path to a new experience offering unlimited capacity and free roaming. In the late 90s, with visitors able to choose their own routes and listen as long as they liked, museums began to accept audio guides as an increasingly versatile and desirable visitor accessory. Suddenly, it was possible to provide multiple languages and custom guides for specialized audiences. The opportunities for broad acceptance by diverse museum audiences led to the emergence of audio guides as a standard museum accessory.

Now, at the beginning of 2003, virtually every major and middle-sized art museum in the world has an audio guide for its permanent collection, often in several languages. Acceptance of portable information appliances in museum has also expanded well beyond art museums. We now find ourselves working in 2003 on productions as diverse as guides for The Statue of Liberty, the Spy Museum and the Museum of Sex.

Broad application has also sparked an interest in universal distribution. More than half the audio guides in the world now are bundled into the ticket price and given away to all visitors. Although this is just one of many distribution formats, the combination of random access and universal distribution has emerged as the audio guide format most favoured by museum visitors. Visitors greatly appreciate the ability to control the sequence and pacing of the tours, particularly for the permanent collection. With audio guides normally renting for five and six dollars, the low, universal per-visitor fee, usually around a dollar, incorporated within the general admission fees, gives the impression of a valuable, free educational service.

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The development path of handheld computing is now bringing us to remarkable new multi-media players. At the same time, the current generation audio-only MP3 players have become highly sophisticated digital devices with tremendous capabilities. The range of features includes the ability to track and download visitor usage patterns, respond to visitor queries, carry multiple languages, provide linear and random access tours, and synch multi-lingual sound tracks to films and videos. Improvements in compression are dramatically expanding the capacity of the players and challenging wireless for the ability to offer unlimited content. This spring Antenna Audio is introducing a player that will allow two gigabytes of memory, enough for 125 hours of high quality sound. At the other end of the spectrum, RSF has introduced a near disposable low cost wand with minimal features eliminating, for instance, the recharging facility.

Museums are also becoming more sophisticated consumers. Whereas in the past the institution might simply ask for an audio guide, now it will request linear or random access, MP3 players, wands, headset devices, radio systems or PDAs.

A surprisingly energetic debate still flourishes around the subject of headsets vs. wands. Conflicting studies show visitor preference for both options (British Museum Study, 2000; Edinburgh Castle Study, 2001; Museum of Fine Arts, Houston Study 2002; Xerox Parc, 2001). Objections to headsets usually focus on the potential to affect the social aspect of a museum visit. Beverly Serrell (1996), for instance, acknowledges the advantages to learning that comes from simultaneous use of ears and eyes, but notes the isolating effect of headsets. The background for this concern is often based on research conducted by Dr. John Falk and Dr. Lynn Dierking at the Institute for Learning Innovation. Falk and Dierking argue that the educational context is enhanced by the social aspect of the museum visit and that interchange among companions leads to an important form of collaborative learning. They identify the museum as an ideal context for this "free choice learning" wherein visitors absorb ideas and connections at random, based on personal interests and triggered lines of inquiry (Falk and Dierking 2000). Drawing on this research, one might conclude that headsets interfere with this dialogue.

However, recent research conducted at the Xerox Palo Alto Research Center, now known as Parc, has refined this argument in the context of new technologies in museum spaces. In the course of their research into screen-based players, Paul Aoki and Allison Woodruff compared text to headsets to built-in speakers as information sources for handhelds. Their results supported other studies that showed that audio was preferred over text as it allowed the visitor to stay focused on the museum display (Woodruff et al. 2001). Visitors particularly liked sound played over hand held speakers, but this was obviously not practical for indoor museums. The Parc team later tested several kinds of headsets with a group of eight Xerox employees and reported a preference for a single earpiece with headband; sort of a telephone operator rig which combines the hands-free convenience of the stereo headset with a 'free ear' for companions (Grinter et al. 2002).

Clearly a headset-based solution will be the default for screen-based players, as you will not be able to hold them up your ear and also see the screen. But it is still possible to give visitors a choice of headset or wand with their audio tour, as the same players now can be used with excellent sound for either option. The preference of visitors for this choice serves to underline that the museum is a center with many different opportunities for personal learning – some benefit from social interaction, while others require the ability to concentrate and in fact be temporarily isolated from companions. Ultimately, the effectiveness of these educational experiences is based on the appropriateness of the technology used for the stated educational or interpretive goals.

The Centrality of the Visitor Experience

With such a variety of technologies on offer, studies of visitor needs and responses have taken on an even more crucial aspect, not only to inform

museums' purchasing decisions today, but also to spur development of visitor interpretation systems for the future. In this spirit, Antenna Audio has introduced the 'TouchPol' touchscreen visitor surveying system into selected museum sites in order to gather visitor response to the audio tour and related issues. In the context of audio-visual handheld systems, CIMI has recognized the rising demand for consistent and effective evaluation tools and is working with Professor Geri Gay and the Cornell HCI Group's concept mapping procedure in the Handscape program "to collect and analyze visitor expectations, museum expectations, potential use scenarios, and the like, as a means of establishing a firm foundation from which future testing may be developed and evaluated." (CIMI 2002)

Similarly, the Multimedia Tour pilot (MMT) conducted at Tate Modern in 2002 took as its primary aim the evaluation of visitor response to the technology and a wide range of approaches to multimedia content design. At the same time, the MMT allowed both Tate Modern and Antenna Audio staff to begin to consider how this technology might fit within the larger interpretation strategy and alongside other interpretation media such as audio tours, wall text, and educational events.

Jane Burton, Curator of Interpretation at Tate Modern, sees the MMT as a sign of times to come for museum interpretation:

> Audio guides have been part of the interpretation and education strategy since Tate Modern opened in May 2000. Having established a reputation for delivering excellent audio tours, Tate Modern would like to remain at the cutting edge of educational technology by helping to shape a new generation of multimedia tours. The advantages of the system we have been testing include the ability to offer content directly in front of the work of art without encroaching on the aesthetics of the gallery space, the potential for creating individualized tours, and for encouraging interactivity (the facility for users to email content home, respond to questions etc). Developing the Tate Modern Multimedia Pilot, in collaboration with Antenna Audio, revealed some pitfalls but predominantly the amazing potential for this new technology, which, in the coming years, will surely take its place alongside more traditional learning tools as a key strand of museum interpretation. *(Burton, 2003)*

The extensive user feedback gathered during this project at Tate Modern can therefore serve as a lens through which to view both the state of the art in museum handhelds and the near future of museum interpretation, as seen not only by the technologists, but more importantly by the museum's visitors.

The Tate Modern Multimedia Tour Pilot

Sponsored by Bloomberg, Tate Modern's Multimedia Tour Pilot was open to the public from July through September 2002. Developed with Tate Modern by Antenna Audio, the multimedia tour was a 45-minute tour of the *Still Life/Object/ Real Life* galleries, in which visitors could experience audio, video, still images and a variety of interactive applications on handheld iPAQ computers loaned by HP. The content of the multimedia tour was delivered to the visitor through the museum's wireless network, using location-based technologies powered by PanGo Networks. Design support for the project was provided by Tate Modern's Web design team, Nykris.

The pilot had a dual purpose: to test both applications of wireless technology in the gallery, and to assess a wide range of approaches to content design. The

wireless network extended over fourteen galleries, defining sixteen unique content zones by means of just seven access points. In each gallery, a different approach to content design was applied to the presentation of a selected object. After their tour, visitors were asked to evaluate the different designs and provide feedback on the overall impact of their experience of the technology.

The pilot was specifically designed to define the limits of the current generation of wireless technology, and therefore involved an ambitious combination of location-based and interactive applications, namely:

- **Interactive survey and response:** the system asked and recorded visitors' opinions of a Nikki de Saint Phalle painting, both before and after they saw a video of its production;
- **Creative play:** visitors could mix their own soundtracks to accompany their viewing of visual collages by Edoardo Paolozzi;
- **Location-specific content delivery:** content was delivered to visitors according to their location in the gallery.
- **Visitor tracking:** the Proximity Platform™ tracked visitors' locations in the galleries, relaying them to a digital map at the distribution desk. This system also alerted staff if a device failed or the visitor otherwise appeared to be in need of technical assistance.
- **Visitor paging:** staff could page visitors *ad hoc* through the PDAs, as well as send out pre-programmed, timed alerts, e.g. regarding the start of a video program in the gallery.
- **Visitor profiling:** the wireless system tracked visitors' use of the content with a record of which exhibits they visited.
- **Visitor e-mail facility:** visitors were able to e-mail themselves further information on objects and artists on the tour in order to follow up on artists and artworks of interest through the Tate Web site.

Visitor Feedback

A wealth of visitor responses was gathered from the pilot: 852 visitors took the pilot tour and completed evaluation forms recording their experiences. These responses were analyzed in a comprehensive database. In addition, the software system used in the trial logged all uses of the MMT and provided a statistical picture of how the tour was utilized, which rooms were visited, and how the visitor e-mail system was used. Not least, Antenna Audio staff demonstrated the tour to a wide range of visitors and specialists, including curators, educators, museum directors, artists, technologists, and wireless solution integrators. In conversation with these experts in their fields, we gained valuable and detailed feedback on the MMT technology, the experience, and ways of improving both.

Although this technically innovative pilot often pushed the technology to its limits and beyond, visitors were enthusiastic about both the service and the tour. Visitors generally see this technology as an exciting and inevitable part of the future landscape in museums. The British Academy of Film and Television Arts agreed that the multimedia tour enhanced the visitor experience at Tate Modern, remarking in its award to Tate Modern and Antenna Audio for Technical Innovation that:

> Genuinely groundbreaking, this was an exciting demonstration of how new technology can be used to enhance museum and gallery visits. Using a hand-held wireless device that knows just where you are on the tour, this offers a stimulating array of material to add to, but not confuse, the experience of a gallery visit. Commendably, Tate Modern is working with day-to-day feedback from visitors to develop a system that complements an already stunning physical learning space. (BAFTA 2002)

In this respect, the trial was a resounding success in demonstrating how such cutting-edge technology can be implemented today in a museum's interpretation

program. It achieved its goals of mapping both the strengths and weaknesses of wireless handheld solutions; however, the true judges of the success or failure of this new technology will be the museum visitors. As a result, the visitor responses gathered during the trial are our most valuable roadmap towards development of handheld technologies for museums in 2003 and beyond.

Visitor Demographics

A primary tool in the collection of visitor response to the MMT was a questionnaire that was completed by all visitors taking the tour: 852 questionnaires were completed by visitors from around the world.

- The largest group of visitors fell in the 26-40 age bracket, with 26% of visitors aged 18-25, 24% aged 41-60, 9% aged 10-17 and 4% over 61.
- 42% of visitors were female, and 58% male;
- 56% of visitors were British;
  18% were North American;
  17% were from Continental Europe.
  8% were from the rest of the world (1% did not respond to this question)

The comparison of this sample with the overall demographics of visitors to Tate Modern indicates that audio-visual tours will be particularly popular with North Americans:

- The MMT attracted more than double the percentage of North American visitors at Tate Modern in this period (18% of MMT users were North American, compared to an overall visitor ratio of only 7%);
- The MMT attracted fewer UK visitors than the average in this period (56% of MMT users were British, compared to an overall of 70% UK visitors to Tate Modern);
- The MMT attracted a similar percentage of European and 'Rest of World' visitors to the Tate Modern standard;
- The MMT attracted more male visitors than the average at Tate Modern: 58% compared to a usual audience of 41% men at Tate Modern;
- The MMT attracted fewer visitors aged over 60 than the Tate Modern average, but 3-5% more visitors in the under-60 age bracket.

Visitor Satisfaction

The average amount of time visitors spent taking the tour was 55 minutes.

Over 70% of visitors spent longer in the gallery, and a similar percentage said that the MMT had improved their visit to Tate Modern.

Approximately 61% of the visitors gave their email addresses in order to be able to use the e-mail feature. The overall content rating the tour received was nearly 7 marks out of 10. The clear conclusion from user response to the tour was that visitors enjoy the tour more when the content is tailored to their interests and ability level. As a 'sampler' of content design approaches, the MMT was geared for a generalist audience with interest in the art on display, but no prior knowledge. Unsurprisingly, then, we found that visitors with extensive art backgrounds were less satisfied by the content on the tour, and would have preferred more research-oriented content and facilities.

Main Difficulties

In general, older visitors found the technology more difficult to use than younger visitors. Overall 55% of visitors found the MMT easy to use, while 45% found it difficult.

Regardless of age, nearly all visitors experienced technical difficulties in using

the new technologies of the MMT. The most requested improvements for the system were making the content easier to access (i.e. by improving the user interface), and making the PDA more reliable.

Technical Findings

The technical performance and ease-of-use of a handheld tour are in fact determined by seven different elements that must work together in order to provide a positive user experience. These are:

The PDA, including:

- **Processing Speed:** the current generation of PDAs have very slow processors, and are roughly comparable to 6-10 year-old desktop computers. They are the 'bottleneck' in the wireless system's ability to delivery media-rich, processor-demanding content to visitors;
- **Operating System Stability:** PocketPC was not originally intended for rich multimedia content and so is not yet optimized for this use; however, there is huge pressure from the PDA manufacturers on Microsoft to make Internet Explorer 5 available on the Pocket PC. A major rewrite and upgrade is expected within the next 6 months (.NET). In addition, alternative operating systems are available, including Pocket Linux, Palm OS 5 and C++ content delivery engines.

The Wireless Network

The 802.11b protocol used at Tate Modern provides an embarrassment of bandwidth - effectively 5mB per second data transfer rate (up to 11mB per second in lab conditions). This is more than twice the speed of a T1 Internet connection. However, the processor in the PDA was not always up to handling the quantity and complexity of files being delivered to it. Delays, therefore, in the playing of content, etc., were due less to network issues than to processor weaknesses.

'Client Side' Software

'Client side' software is stored locally on the PDA, and includes Internet Explorer for PocketPC 2002 and Macromedia Flash v. 5, the file format in which the tour's multimedia content was programmed.

'Server Side' Software

'Server side' software is stored on the network server, including the content delivery engine (PanGo's Museum Docent™) and its applications that allowed us to create content in industry-standard formats such as HTML and Flash and deliver it to the user. The Museum Docent™ software and its applications proved to be very stable; indeed, the software did not crash during the entire pilot period.

Special features of the Museum Docent™ software include:

- **Full Screen Content Mode:** so that it was not necessary to sacrifice any screen real estate to the Internet Explorer browser window;
- **Paging Service:** allowing the distribution desk to contact visitors using the tour through the PDA;
- **Alerts Service:** automatically prompting the visitors before each start of the Jan Svankmajer video sequence;
- **e-Phile Service:** allowing visitors to bookmark information of interest and e-mail it to themselves.

The Location-Based Service (LBS)

The LBS provides location-sensitive content delivery and location-sensitive interactive maps of the gallery. PanGo's Proximity Platform™ calculates the location of the user by taking signal strength readings from a number of access points in the user's vicinity and effectively 'triangulating' the user's position. In the MMT pilot, we were able to define 16 distinct content zones by using only 7 access points - a significant cost saving over earlier location-based systems in terms of network installation and maintenance. Limitations of the Proximity Platform™ include:

- Minimum location granularity of 1 meter in ideal conditions; in practice, 3 meters;
- Ambiguity in 'border spaces' and overlapping content zone areas;
- 2-3 second latency for accurate location identification.

Design

Design issues include three aspects of the tour:

- Tour Experience Design;
- Tour Interface Design;
- Tour Content Design.

Each design element has not just a visual impact on the user, but also a logical impact: just as each message is structured according to an interpretive or pedagogical logic, so the navigation icons and their arrangement on the screen reflect basic assumptions about the use and the organizing principles of the tour experience. Together the interface and content should support the desired Tour Experience. It is important when evaluating feedback from users to distinguish between these two elements, and also to keep in mind that the tour was not conceived as a united 'Experience'. Instead, the purpose of the pilot was to test a variety of approaches to the content design, as well as the technology and visitor feedback to it.

Human-Machine Interface

The form factor and weight of the PDA, as well as the screen and battery life, also impacted the way the visitors interacted with the MMT. In particular, the following aspects presented challenges to the operations of the pilot project:

Battery life and charging: The iPAQ's screen drains enormous power from the PDA. Although HP provided very helpful guidance in setting up the PDAs for maximum power saving, we still had to leave the screen on constant, high brightness in order to provide the best possible user experience. As a result, the battery power and therefore performance of the iPAQ deteriorated after approximately 1.5 hours of use. The iPAQ would then need to be recharged for approximately one hour in order to reach full battery power again. This severely limited the number of uses each iPAQ could have in a day.

Smaller, lighter devices with integrated wireless cards and greater battery life significantly improve the user experience of the PDA. The batteries used in the 3900 series iPAQs and the new 5000 series provide both longer life and better power management. HP's new X-Scale-based 5000 series iPAQs with integrated wireless include a removable lithium polymer battery, so it's possible to keep spare batteries charged up in order to minimize down time during recharging. These iPAQs also include the better quality screen that is already in the 3900 series iPAQs, and the stronger X-Scale processor. Toshiba, Acer, and Symbol also offer PDAs with integrated wireless cards which improve not just the battery life but also the ergonomics of the device. Antenna Audio is currently developing mass charging facilities that will be compatible with industry-leading PDAs.

Weight: Many users found the iPAQ too heavy to carry for long periods. Although the large straps distributed the weight more evenly across users' necks,

the width made them uncomfortable with many people's clothing. Small children were not able to use the devices for very long because of their weight.

Fragility: In order to protect the PDA, it was given to the visitor in a rugged case which increased the weight of the PDA. However, we found that this level of ruggedization was sufficient to protect the device. In three months of use, we had no breakage, though several devices were dropped.

Screen: In general, users are happy with the size of the standard PDA screen, as long as the content is designed well for it. In particular, content design needs to take into account the screen's 'high contrast' structure, designed to make the screen legible out doors, which can render extreme darks and light colors illegible. Resolution also helps the legibility of the screen enormously, and we saw a marked improvement in the screens used in the 3900 series.

Content Findings and Recommendations

In addition to testing the technology and visitors' responses to it, the primary aim of the MMT pilot was to test a variety of approaches to content design. The content proved to be the primary draw of the MMT, and indeed it will be the quality of the content that ultimately determines the success or failure of the tour experience. In many respects each new object demands a new approach, so accumulating a design guide of what works and what doesn't is likely to take as long if not longer to develop than the technology.

The findings and recommendations made below regarding content design are based on Antenna staff experiences, the questionnaires, and feedback from Susie Fisher, the independent evaluator hired by Tate Modern.

What Worked

Interestingly, users did not seem to find multi-tasking and multi-tracking of different media (e.g. looking between screen and artwork) to be a problem as long as the message was well designed and the PDA was functioning properly. The multimedia tour clearly had the effect of making the visitors look longer at an object than they would have otherwise, even though the screen was also commanding attention. As Susie Fisher reported, "Visitors can multi track with great ease, even when the input tracks (audio, screen, painting) are not synchronized with one another." (Fisher, 2002, Chart 34)

In this regard, "audio acts like a friend", and indeed more use could be made of the audio to direct the users' eye movements between the object, and the screen, and to navigate through the gallery space.

In both the questionnaires and Focus Groups, visitors' favorite stops on the tour featured the following design approaches:

Audio-Visual Coherence: A strong logical link between the audio and the visual worked well in messages where an audio description of abstract paintings by Braque and Auerbach was accompanied by visual 'zooming' into the details being discussed; however, it is important to note that at least in the case of the Braque message, the 'audio focusing' of the message that explained the painting's various elements could have been accomplished with audio alone. The Auerbach painting, on the other hand, is more abstract and therefore really benefited from the explanatory visual details. Susie Fisher's advice here is apt: "Use the visual to do things which can only be done visually" (Fisher, 2002, Chart 32).

Interactives: Interactive messages, in which visitors had a chance to register their opinions about a *Shooting Picture* (by Niki de Saint Phalle) and create their own soundtracks to listen to while viewing collages by Edoardo Paolozzi, were very popular. Visitors asked that the interactivity be enhanced further, for

example, by showing them how other visitors responded to Saint Phalle's work, and by allowing them to save or send their Bunk soundtrack combinations.

Audio: Visitors responded enthusiastically to messages that included interviews with artists, sitters, and related experts, as the speakers were relevant and interesting. A porno-movie-style soundtrack by the Chapman Brothers entertained with its shock effect, but it also alienated other visitors. It became clear that good audio navigational instructions are also a core skill, required by both the MMT and the traditional audio tour, since moving visitors around the galleries safely and effectively is fundamental to the success of any tour.

Video: Perhaps surprisingly, video was not the focus of praise for the message that showed artist Niki de Saint Phalle creating a *Shooting Painting*. Instead, visitors most commented on how much they enjoyed the process of learning in this message, where they had the opportunity to give an opinion of the work both before seeing the video, and afterwards. Using the screen to explain the process of making a work was considered by several visitors to be a good use of the screen, but the video was also considered a potential distraction;

Intuitive, Interactive Interfaces: A message about Damien Hirst's *Pharmacy* used a 360 degree panorama of the installation as the interface for audio messages about the work, much in the style used by the Parc researchers at the Filioli Mansion. Although this room was de-installed early on in the project and therefore was not in the focus group analysis, it was very popular among visitors for the ease of use of its interface as well as for the interviews with the artist and a pharmacist which it included.

What Didn't Work:

Long Messages: Visitors seemed to tire more easily from the interactive tour than from more passive audio tour experiences. In addition, the screen seems to make them expect more to happen, more quickly, than in an audio tour. It is likely, therefore, that multimedia messages need to be shorter than audio tour messages, but to offer the visitor more second level message options. The PDA screen, which can display several second level options, makes this possible, in contrast to audio tours where it is more difficult to offer multiple message 'layers' because of the difficulty of remembering their number combinations. However, as in audio tours, second level options can be a useful way of dispersing audiences by directing them to related works, e.g., so that they don't spend a long time bunched in front of a few selected works in each gallery;

Blank Screens: We intentionally made the screen go relatively blank at selected points along the tour, in order to focus visitor attention on the art object. Visitor feedback indicated that we were probably too conservative in this: they found the blank screen confusing, and wondered if something were wrong with the PDA. The screen demands that at least a still image of the object being discussed appear on the screen at all times, as much to identify the object of discussion and reassure the visitor that the PDA is working as anything. Regarding our fears that visitors would spend their time in the galleries 'with their eyes glued to a small television screen', one visitor comment seemed to sum up the lack of danger: "there is no way the small digital image of the object could be more compelling than looking at the real thing." Here, as ever, good content design is key to the tour, producing a beneficial rather than distracting visitor experience;

Text: Text had a mixed response: some - particularly more 'art experienced' visitors, liked having wall labels in the palm of their hand, while others wanted more exciting content;

Help Menu: The lack of a help menu was felt, as visitors needed to be able to refer to a key to the navigation icons throughout their tour, to remind them of the functions and options available to them.

And Moreover:

- Visitors wanted MORE of everything: more objects on the tour, and more information about each.
- Just as in audio tours, the multimedia tour can take attention away from other objects in the gallery, items which are not on the tour. Therefore careful tour design is essential.

User-Interface

Interface buttons and Functions

The MMT used the following interface buttons:

- Map
- Information
- What's Here
- E-Phile
- Rewind
- Pause/More

The icons and functions of these buttons were often quite unclear to users, and there were several functions that users missed and requested. This response pointed to the fact that this new technology requires new functions that are not yet known, let alone intuitive, to the general public. In response to this feedback from the Tate pilot, Antenna Audio is redesigning the interface and multimedia tour functionality, and will be working with Tate Modern to refine these further.

Content Menus

In order not to interrupt or control the visitors' experience of the tour, the MMT was designed to leave the launching of content entirely in the hands of the visitors; although the content could have been triggered by the location of the visitor to play automatically, the visitor had to press the 'What's Here' button or choose a room from the map in order to trigger its content to play.

We found, however, that there was demand for an automatically-generated menu of content available in each gallery, to both respond to the visitor's movements and prompt the visitor to explore new content. This demand can be satisfied through the Proximity Platform's™ 'aggressive' location sensing mode. When a message stops playing on the device, and the user is not receiving any content, the Proximity Platform™ will go into 'aggressive' mode, sending a Local Area Menu of information relevant to the user's immediate area to the PDA's screen. This menu will not interrupt any content the user is currently playing; it will only appear if the user is not currently playing content. Alternatively, users can specifically request the content menu for their local area at any point in the tour.

Customer Service Findings and Recommendations

Distribution Desk and Management Console

At the distribution desk's computer terminal, the Museum Docent™ displayed a map that tracked the location of users in the gallery as they took the tour. This and the 'checking in/out' system, which allowed staff to associate a visitor's name and email address with the PDA, and hence with the location on the gallery-tracking map, were particularly useful for security and tour management. Similarly, the server-side usage logs, which tracked where visitors went, which messages they accessed, etc., proved particularly helpful in evaluating the success of the pilot.

The Museum Docent™ also includes a client-side log, which sits on each PDA and tracks any problems that occur and why. This performance log proved essential to monitoring PDA performance.

Distribution and End-User Training

The MMT was emphatically represented to the public as a pilot; by being given the tour for free, and being asked to fill in evaluation forms, the public was reminded that the aim of the installation was to gather information in order to improve and develop the service further.

The best way to distribute the PDAs and teach visitors how to use them was a constant work in process. Even the distribution desk underwent various permutations, as various storage and presentation facilities became available.

The navigation button icons were difficult for visitors to understand and remember, and posed a particular challenge to instructing visitors in the use of the device. It could take upwards of 5 minutes to teach each visitor how to use the tour.

Visitors' credit cards or other major documents were held as security for the PDA. With only 15 PDAs, keeping track of these did not pose any difficulties for distribution staff.

Security

Despite the lack of equipment security at the distribution desk, there were no equipment thefts during the trial. Nor were there any breakages.

The location-sensitive map on the distribution desk proved useful in tracking devices. On one occasion, a couple clearly left the tour area and 'dropped off' the tracking map on the distribution desk. However, because the wireless network coverage extended beyond the tour area, staff were able to send a page to the couple, asking them to return to the distribution desk. They did so and returned the devices, explaining that they had simply gone to the café and had forgotten to bring the PDAs back first.

A Glimpse of the Future for Handhelds and Museums: The m-ToGuide Project

The m-ToGuide (mobile tourist guide) project is funded by the European Union as part of the IST (Information Society Technology) programs, 5th Framework. In 2001, the IST commission made a total of EU 25 million available for 5 projects to be conducted towards the development of next generation telephone technologies and businesses in Europe. The aim of these projects is to develop technologies and build business for next generation telecoms, by creating consumer demand for new services and hence jobs in the sector.

Motorola's research and development division, Motorola GTSS, headquartered in Israel, assembled the m-ToGuide group, a consortium of 17 companies including Antenna Audio, to respond to this call. The team was awarded a €5.5 million grant in April 2002. The m-ToGuide service will integrate tourist content and services from a variety of providers, delivering these to the end-users' handheld terminals (PDA) via 2.5 and 3G telephone networks.

Currently, 3G networks are not truly available for the m-ToGuide service, so initial trials will be conducted using a combination of locally-stored content and the slower GPRS or 2.5G network infrastructure to transfer low-bandwidth data to the terminal. Positioning will be provided by GPS, but the system is designed to receive location information from a variety of other inputs as well, including cell id, the system used by the current generation of phones (GSM). Cell id is the least precise positioning system available, locating the user only within approximately 500 sq meters, while 'assisted GPS', using GPS plus positioning software, can achieve up to approximately 3 meters accuracy.

The m-ToGuide service is intended to replace and enhance the navigation and information services currently available to tourists, via a handheld device, a kind of PDA, connected to high-speed telephone networks (GPRS or 2.5G and UMTS or 3G). Equipped with location-sensitivity (GPS and cell id), the m-ToGuide terminal will provide interactive navigation services and personalized information, according to criteria established by the users, on places of interest, monuments, stores, restaurants, hotels, museums, opening hours, etc. It is also being developed to include m-commerce facilities, allowing the users to buy tickets and make bookings. Trials of the service will be carried out in Madrid, Sienna and London in summer 2003.

Antenna Audio is responsible for developing audio visual and textual messages for the main points of interest of each city in the project. This 'highlights tour' of each city may be supplemented by other tours, for example an audio-visual tour of a museum, current exhibition, or other visual attraction. The tourist can then use a single handheld device to tour both interior and exterior spaces, receiving both media-rich interpretation of features and attractions as well as practical, navigational support from maps and visitor information. A primary aim of Antenna Audio's involvement in this project is to use the technology to develop new audiences and means of reaching those audiences, as well as new revenues and commercial opportunities, for our museum partners.

In addition to providing the London tour content, Antenna Audio led the research that defined users' needs and requirements for this new city tour technology. In summer 2003, Antenna Audio will put its learning from this and the Tate Modern pilot into action as it staffs and runs the distribution operations and user support services for the London field trial. As in the Tate Modern MMT, user surveying and evaluation will be a main activity and goal for the m-ToGuide project.

Conclusion

The development of next-generation museum handhelds is being informed by the experience gained from millions of audio guide users over the past three decades. The fundamental benchmarks for successful mobile learning experiences are now well known, allowing us to concentrate on new features and opportunities.

Wireless interactive systems offer important tools and unique opportunities for the development of in-gallery interpretation and education programs, and the extension of these to a cultural experience of the wider city that links many museums and visitor attractions. The visitor response to the Tate Modern Multimedia Tour Pilot has given an unequivocal green light to future development of these handheld solutions within the museum. We now look forward to the results of the m-ToGuide project as cultural tourists guide the development of mobile, interactive technologies beyond the museum's wall as well.

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